

IN THE ABSTRACT:

Please delete the abstract and substitute therefore the following:

2
A stent, or device for repair and reconstruction of the spinal disc wall, or annulus fibrosus, after surgical incision or pathologic rupture, which is inserted through an aperture into the subannular space. The stent has radial extensions which are caused or allowed to expand into an expanded configuration to bridge the aperture. The stent thereby occludes the defective region from the inside of the vertebral disc and prevents the migration of nucleus pulposus therethrough, while also providing a scaffold for tissue growth.

IN THE SPECIFICATION:

Please replace the paragraph starting at page 1, line 12 and extending to page 1, line 17 with the following amended paragraph:

B3 [002] The invention generally relates to a surgical method of intervertebral disc wall reconstruction. The invention also relates to an annular repair device, or stent, for annular disc repair. The effects of said reconstruction are restoration of disc wall integrity and reduction of the failure rate (3-21%) of a common surgical procedure (disc fragment removal or discectomy). This surgical procedure is performed about 390,000 times annually in the United States.

Please replace the paragraph starting at page 2, line 9 and extending to page 2, line 20 with the following amended paragraph:

B4 [005] The aging process contributes to gradual changes in the intervertebral discs. The annulus loses much of its flexibility and resilience, becoming more dense and solid in composition. The aging annulus is also marked by the appearance on propagation of cracks or fissures in the annular wall. Similarly, the nucleus dessicates, increasing viscosity and thus losing its fluidity. In combination, these features of the aged intervertebral discs result in less dynamic stress distribution because of the more viscous nucleus pulposus, and less ability to withstand localized stresses by the annulus fibrosus due to its dessication, loss of flexibility and the presence of fissures. Occasionally fissures may form rents through the annular wall. In these instances, the nucleus pulposus is urged outwardly from the subannular space through a rent, often into the spinal column. Extruded nucleus pulposus can, and often does, mechanically press on the spinal cord or spinal nerve rootlet. This painful condition is clinically referred to as a ruptured or herniated disc.

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Please replace the paragraph starting at page 2, line 21 and extending to page 3, line 8 with the following amended paragraph:

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[006] In the event of annulus rupture, the subannular nucleus pulposus migrates along the path of least resistance forcing the fissure to open further, allowing migration of the nucleus pulposus through the wall of the disc, with resultant nerve compression and leakage of chemicals of inflammation into the space around the adjacent nerve roots supplying the extremities, bladder, bowel and genitalia. The usual effect of nerve compression and inflammation is intolerable back or neck pain, radiating into the extremities, with accompanying numbness, weakness, and in late stages, paralysis and muscle atrophy, and/or bladder and bowel incontinence. Additionally, injury, disease or other degenerative disorders may cause one or more of the intervertebral discs to shrink, collapse, deteriorate or become displaced, herniated, or otherwise damaged and compromised.

Please replace the paragraph starting at page 4, line 2 and extending to page 4, line 4 with the following amended paragraph:

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[010] The present invention provides methods and related materials for reconstruction of the disc wall in cases of displaced, herniated, ruptured, or otherwise damaged intervertebral discs. In accordance with the invention, an annulus stent is disclosed for repair of an intervertebral disc annulus, comprising a centralized hub section, said hub section comprising lateral extensions from the hub section.

Please replace the paragraph starting at page 4, line 5 and extending to page 4, line 8 with the following amended paragraph:

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[011] In an exemplary embodiment, one or more mild biodegradable surgical sutures are placed at about equal distances along the sides of a pathologic aperture in the ruptured disc wall (annulus) or along the sides of a surgical incision in the annular wall, which may be weakened or thinned.

Please replace the paragraph starting at page 4, line 15 and extending to page 4, line 20 with the following amended paragraph:

[014] In another embodiment, the method can be augmented by creating a subannular barrier in and across the aperture by placement of a patch of human muscle fascia (the membrane covering the muscle) or any other autograft, allograft, or xenograft acting as a bridge or a scaffold, providing a platform for

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traverse of fibroblasts or other normal cells of repair existing in and around the various layers of the disc annulus, prior to closure of the aperture.

Please replace the paragraph starting at page 5, line 1 and extending to page 5, line 9 with the following amended paragraph:

9/17/03
B9
[016] Having demonstrated that human muscle fascia is adaptable for annular reconstruction, other ^{biocompatible} ~~biocompatible~~ membranes can be employed as a bridge, stent, patch or barrier to subsequent migration of the disc nucleus through the aperture. Such biocompatible materials may be, for example, medical grade biocompatible fabrics, biodegradable polymeric sheets, or form fitting or non-form fitting fillers for the cavity created by removal of a portion of the disc nucleus pulposus in the course of the disc fragment removal or discectomy. The prosthetic material can be placed in and around the intervertebral space, created by removal of the degenerated disc fragments.

Insert the following new paragraphs after paragraph [016] and before the title "Brief Description of the Drawings."

B10
[New] Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims.

[New] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

Insert the following new paragraph preceding paragraph [017] and following the title "Brief Description of the Drawings."

B11
[New] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate illustrative embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Please replace the paragraph at page 5, line 14 with the following amended paragraph:

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[017] FIG. 1 shows a perspective view of an illustrative embodiment of an annulus stent.

Please replace the paragraph at page 5, line 12 with the following amended paragraph:

[018] FIG. 2 shows a front view of the annulus stent of FIG. 1.

Please replace the paragraph at page 5, line 13 with the following amended paragraph:

[019] FIG. 3 shows a side view of the annulus stent of FIG. 1.

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Please replace the paragraph starting at page 5, line 14 extending to line 15 with the following amended paragraph:

[020] FIGs. 4A-4C show a front view of alternative illustrative embodiments of an annulus stent.

Please replace the paragraph starting at page 5, line 16 extending to line 17 with the following amended paragraph:

[021] FIGs. 5A-5B show the alternative embodiment of a further illustrative embodiment of an annulus stent.

Please replace the paragraph starting at page 5, line 18 extending to line 19 with the following amended paragraph:

[022] FIGs. 6A-6B show the alternative embodiment of a further illustrative embodiment of an annulus stent.

Please replace the paragraph starting at page 5, line 20 extending to line 21 with the following amended paragraph:

[023] FIG. 7 shows a primary closure of an opening in the disc annulus.

Please replace the paragraph starting at page 5, line 22 extending to line 23 with the following amended paragraph:

[024] FIGs. 8A-8B show a primary closure with a stent.

Please replace the paragraph starting at page 6, line 1 extending to line 2 with the following amended paragraph:

[025] FIG. 9 shows a method of suturing an annulus stent into the disc annulus, utilizing sub-annular fixation points.

Please replace the paragraph starting at page 6, line 3 extending to line 4 with the following amended paragraph:

[026] FIGs. 10A-10B show a further illustrative embodiment of an annulus stent with flexible bladder being expanded into the disc annulus.

Please replace the paragraph starting at page 6, line 5 extending to line 6 with the following amended paragraph:

[027] FIGs. 11A-11D show an annulus stent being inserted into the disc annulus.

Please replace the paragraph starting at page 6, line 7 extending to line 8 with the following amended paragraph:

[028] FIGs. 12A- 12B show an annulus stent with a flexible bladder being expanded.

Please replace the paragraph starting at page 6, line 11 extending to line 13 with the following amended paragraph:

[029] Reference will now be made in detail to an illustrative embodiment of the invention, which appears in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Please replace the paragraph starting at page 6, line 14 extending to line 23 with the following amended paragraph:

[030] In one embodiment of the present invention, as shown in FIG. 7, a damaged annulus 42 is repaired by use of surgical sutures 40. One or more

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surgical sutures 40 are placed at about equal distances along the sides of a pathologic aperture 44 in the annulus 42. Reapproximation or closure of the aperture 44 is accomplished by tying the sutures 40 so that the sides of the aperture 44 are drawn together. The reapproximation or closure of the aperture 44 enhances the natural healing and subsequent reconstruction by the natural tissue (e.g., fibroblasts) crossing the now surgically narrowed gap in the annulus 42. Preferably, the surgical sutures 40 are biodegradable, but permanent non-biodegradable may be utilized.

Please replace the paragraph starting at page 7, line 1 extending to line 10 with the following amended paragraph:

[031] Additionally, to repair a weakened or thinned wall of a disc annulus 42, a surgical incision is made along the weakened or thinned region of the annulus 42 and one or more surgical sutures 40 can be placed at about equal distances laterally from the incision. Reapproximation or closure of the incision is accomplished by tying the sutures 40 so that the sides of the incision are drawn together. The reapproximation or closure of the incision enhances the natural healing and subsequent reconstruction by the natural tissue crossing the now surgically narrowed gap in the annulus 42. Preferably, the surgical sutures 40 are biodegradable, but permanent non-biodegradable materials may be utilized.

Please replace the paragraph starting at page 7, line 11 extending to line 16 with the following amended paragraph:

[032] In an alternative embodiment, the method can be augmented by the placement of a patch of human muscle fascia or any other autograft, allograft or xenograft in and across the aperture 44. The patch acts as a bridge in and across the aperture 44, providing a platform for traverse of fibroblasts or other normal cells of repair existing in and around the various layers of the disc annulus 42, prior to closure of the aperture 44.

Please replace the paragraph starting at page 7, line 17 extending to line 22 with the following amended paragraph:

[033] In a further embodiment, as shown in FIGs. 8A-B a biocompatible membrane can be employed as an annulus stent 10, being placed in and across the aperture 44. The annulus stent 10 acts as a bridge in and across the aperture 44, providing a platform for a traverse of fibroblasts or other normal cells of repair existing in and around the various layers of the disc annulus 42, prior to closure of the aperture 44.

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Please replace the paragraph starting at page 7, line 23 and extending to page 8, line 3 with the following amended paragraph:

[034] In an illustrative embodiment, as shown in FIGs. 1-3, the annulus stent 10 comprises a centralized vertical extension 12, with an upper section 14 and a lower section 16. The centralized vertical extension 12 can be trapezoid in shape through the width and may be from about 8mm - 12mm in length.

Please replace the paragraph starting at page 8, line 4 extending to line 10 with the following amended paragraph:

B12
[035] Additionally, the upper section 14 of the centralized vertical extension 12 may be any number of different shapes, as shown in FIGs. 4A and 4B, with the sides of the upper section 14 being curved or with the upper section 14 being circular in shape. Furthermore, the annulus stent 10 may contain a recess between the upper section 14 and the lower section 16, enabling the annulus stent 10 to form a compatible fit with the edges of the aperture 44.

Please replace the paragraph starting at page 8, line 11 extending to line 17 with the following amended paragraph:

[036] The upper section 14 of the centralized vertical extension 12 can comprise a slot 18, where the slot 18 forms an orifice through the upper section 14. The slot 18 is positioned within the upper section 14 such that it traverses the upper section's 14 longitudinal axis. The slot 18 is of such a size and shape that sutures, tension bands, staples or any other type of fixation device known in the art may be passed through, to affix the annulus stent 10 to the disc annulus 42.

Please replace the paragraph starting at page 8, line 18 extending to line 23 with the following amended paragraph:

[037] In an alternative embodiment, the upper section 14 of the centralized vertical extension 12 may be perforated. The perforated upper section 14 contains a plurality of holes that traverse the longitudinal axis of upper section 14. The perforations are of such a size and shape that sutures, tension bands, staples or any other type of fixation device known the art may be passed through, to affix the annulus stent 10 to the disc annulus 42.

Please replace the paragraph starting at page 9, line 1 extending to line 12 with the following amended paragraph:

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[038] The lower section 16 of the centralized vertical extension 12 can comprise a pair of lateral extensions, a left lateral extension 20 and a right lateral extension 22. The lateral extensions 20 and 22 comprise an inside edge 24, an outside edge 26, an upper surface 28, and a lower surface 30. The lateral extensions 20 and 22 can have an essentially constant thickness throughout. The inside edge 24 is attached to and is about the same length as the lower section 16. The outside edge 26 can be about 8mm-16mm in length. The inside edge 24 and the lower section 16 meet to form a horizontal plane, essentially perpendicular to the centralized vertical extension 12. The upper surface 28 of the lateral extensions 20 and 22 can form an angle from about 0°-60° below the horizontal plane. The width of the annulus stent 10 may be from about 3mm-5mm.

Please replace the paragraph starting at page 9, line 13 extending to line 15 with the following amended paragraph:

[039] Additionally, the upper surface 28 of the lateral extensions 20 and 22 may be barbed for fixation to the inside surface of the disc annulus 42 and to resist expulsion through the aperture 44.

Please replace the paragraph starting at page 9, line 16 extending to line 18 with the following amended paragraph:

[040] In an alternative embodiment, as shown in FIG. 4B, the lateral extensions 20 and 22 have a greater thickness at the inside edge 24 than at the outside edge 26.

Please replace the paragraph starting at page 9, line 19 extending to line 21 with the following amended paragraph:

[041] In an illustrative embodiment, the annulus stent 10 is a solid unit, formed from one or more of the flexible resilient biocompatible or bioresorbable materials well known in the art.

Please replace the paragraph starting at page 9, line 22 and extending to page 10, line 11 with the following amended paragraph:

[042] For example, the annulus stent 10 may be made from: a porous matrix or mesh of biocompatible and bioresorbable fibers acting as a scaffold to regenerate disc tissue and replace annulus fibrosus as disclosed in, for example, U. S. Patent Nos. 5,108,438 (Stone) and 5,258,043 (Stone), a strong network of inert fibers intermingled with a bioresorbable (or bioabsorbable)

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B2
material which attracts tissue ingrowth as disclosed in, for example, U.S. Patent No. 4,904,260 (Ray et al.);
a biodegradable substrate as disclosed in, for example, U.S. Patent No. 5,964,807 (Gan et al.); or
an expandable polytetrafluoroethylene (ePTFE), as used for conventional vascular grafts, such as those sold by W.L. Gore and Associates, Inc. under the trademarks GORE-TEX and PRECLUDE, or by Impira, Inc. under the trademark IMPRA.

Please replace the paragraph starting at page 10, line 15 extending to line 19 with the following amended paragraph:

[044] Additionally, the annulus stent 10 may comprise materials to facilitate regeneration of disc tissue, such as bioactive silica-based materials that assist in regeneration of disc tissue as disclosed in U.S. Patent No. 5,849,331 (Ducheyne, et al.), or other tissue growth factors well known in the art.

Please replace the paragraph starting at page 10, line 20 and extending to page 11, line 2 with the following amended paragraph:

B3
[045] In further embodiments, as shown in FIGs. 5AB-6AB, the left and right lateral extensions 20 and 22 join to form a solid pyramid or cone. Additionally, the left and right lateral extensions 20 and 22 may form a solid trapezoid, wedge, or bullet shape. The solid formation may be a solid biocompatible or bioresorbable flexible material, allowing the lateral extensions 20 and 22 to be compressed for insertion into aperture 44, then to expand conforming to the shape of the annulus' 42 inner wall.

Please replace the paragraph starting at page 11, line 3 extending to line 10 with the following amended paragraph:

[046] Alternatively, a compressible core may be attached to the lower surface 30 of the lateral extensions 20 and 22, forming a pyramid, cone, trapezoid, wedge, or bullet shape. The compressible core may be made from one of the biocompatible or bioresorbable resilient foams well known in the art. The core can also comprise a fluid-expandable membrane, e.g., a balloon. The compressible core allows the lateral extensions 20 and 22 to be compressed for insertion into aperture 44, then to expand conforming to the shape of the annulus' 42 inner wall and to the cavity created by pathologic extrusion or surgical removal of the disc fragment.

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Please replace the paragraph starting at page 11, line 11 extending to line 17 with the following amended paragraph:

[047] In an illustrative method of use, as shown in FIGs. 11A-D, the lateral extensions 20 and 22 are compressed together for insertion into the aperture 44 of the disc annulus 42. The annulus stent 10 is then inserted into the aperture 44, where the lateral extensions 20, 22 expand. In an expanded configuration, the upper surface 28 can substantially conform to the contour of the inside surface of the disc annulus 42. The upper section 14 is positioned within the aperture 44 so that the annulus stent 10 may be secured to the disc annulus 42, using means well known in the art.

Please replace the paragraph starting at page 11, line 18 and extending to page 12, line 4 with the following amended paragraph:

[048] In an alternative method, where the length of the aperture 44 is less than the length of the outside edge 26 of the annulus stent 10, the annulus stent 10 can be inserted laterally into the aperture 44. The lateral extensions 20 and 22 are compressed, and the annulus stent 10 can then be laterally inserted into the aperture 44. The annulus stent 10 can then be rotated inside the disc annulus 42, such that the upper section 14 can be held back through the aperture 44. The lateral extensions 20 and 22 are then allowed to expand, with the upper surface 28 contouring to the inside surface of the disc annulus 42. The upper section 14 can be positioned within, or proximate to, the aperture 44 in the subannular space such that the annulus stent 10 may be secured to the disc annulus, using means well known in the art.

Please replace the paragraph starting at page 12, line 5 extending to line 23 with the following amended paragraph:

[049] In an alternative method of securing the annulus stent 10 in the aperture 44, as shown in FIG. 9, a first surgical screw 50 and second surgical screw 52, with eyeholes 53 located at the top of the screws 50 and 52, are opposingly inserted into the adjacent vertebrae 54 and 56 below the annulus stent 10. After insertion of the annulus stent 10 into the aperture 44, a suture 40 is passed down through the disc annulus 42, adjacent to the aperture 44, through the eye hole 53 on the first screw 50 then back up through the disc annulus 42 and through the orifice 18 on the annulus stent 10. This is repeated for the second screw 52, after which the suture 40 is secured. One or more surgical sutures 40 are placed at about equal distances along the sides of the aperture 44 in the disc annulus 42. Reapproximation or closure of the aperture 44 is accomplished by tying the sutures 40 in such a fashion that the sides of the aperture 44 are drawn together.

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The reapproximation or closure of the aperture 44 enhances the natural healing and subsequent reconstruction by the natural tissue crossing the now surgically narrowed gap in the annulus 42. Preferably, the surgical sutures 40 are biodegradable but permanent non-biodegradable forms may be utilized. This method should decrease the strain on the disc annulus 42 adjacent to the aperture 44, precluding the tearing of the sutures through the disc annulus 42.

Please replace the paragraph starting at page 13, line 1 extending to page line 4 with the following amended paragraph:

[050] It is anticipated that fibroblasts will engage the fibers of the polymer or fabric of the intervertebral disc stent 10, forming a strong wall duplicating the currently existing condition of healing seen in the normal reparative process.

Please replace the paragraph starting at page 13, line 5 extending to line 15 with the following amended paragraph:

[051] In an additional embodiment, as shown in FIGs. 10A-B, a flexible bladder 60 is attached to the lower surface 30 of the annulus stent 10. The flexible bladder 60 comprises an internal cavity 62 surrounded by a membrane 64, where the membrane 64 is made from a thin flexible biocompatible material. The flexible bladder 60 is attached to the lower surface 30 of the annulus stent 10 in an unexpanded condition. The flexible bladder 60 is expanded by injecting a biocompatible fluid or expansive foam, as known in the art, into the internal cavity 62. The exact size of the flexible bladder 60 can be varied for different individuals. The typical size of an adult nucleus is about 2 cm in the semi-minor axis, 4 cm in the semi-major axis, and 1.2 cm in thickness.

Please replace the paragraph starting at page 13, line 18 extending to line 23 with the following amended paragraph:

[053] In an illustrative embodiment, a hydrogel is injected into the internal cavity 62 of the flexible bladder 60. A hydrogel is a substance formed when an organic polymer (natural or synthetic) is cross-linked via, covalent, ionic, or hydrogen bonds to create a three-dimensional open-lattice structure, which entraps water molecules to form a gel. The hydrogel may be used in either the hydrated or dehydrated form.

Please replace the paragraph starting at page 14, line 1 extending to line 10 with the following amended paragraph:

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